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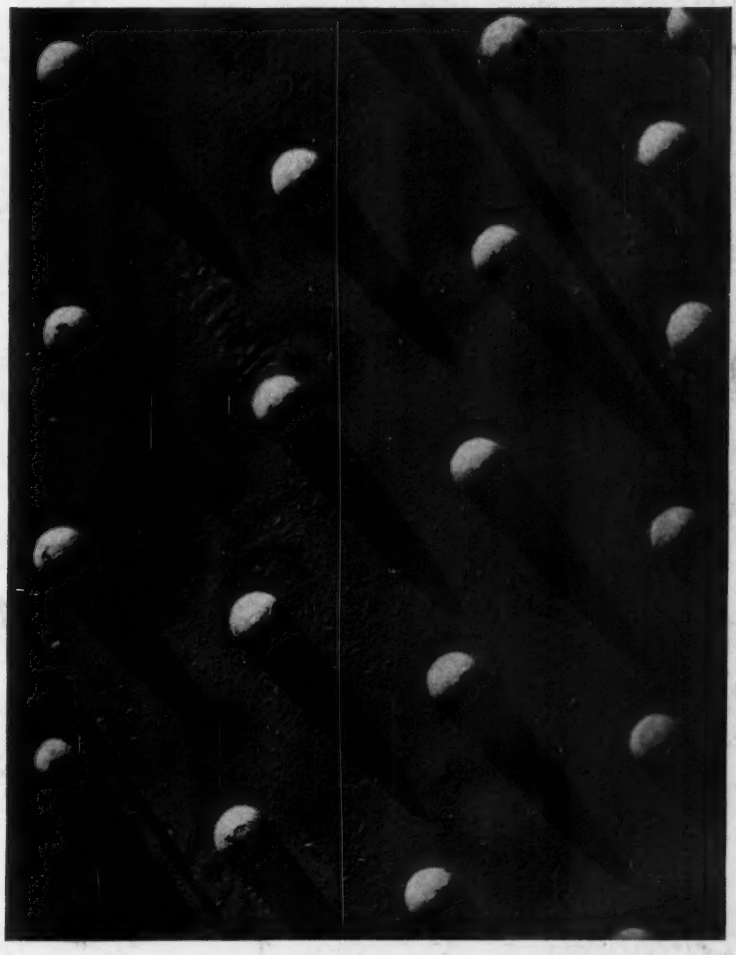

ASTRONOMICAL PROGRESS

AIR CONDITIONING

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THE TECH ENGINEERING NEWS

DECEMBER, 1934
VOLUME XV
NUMBER 6

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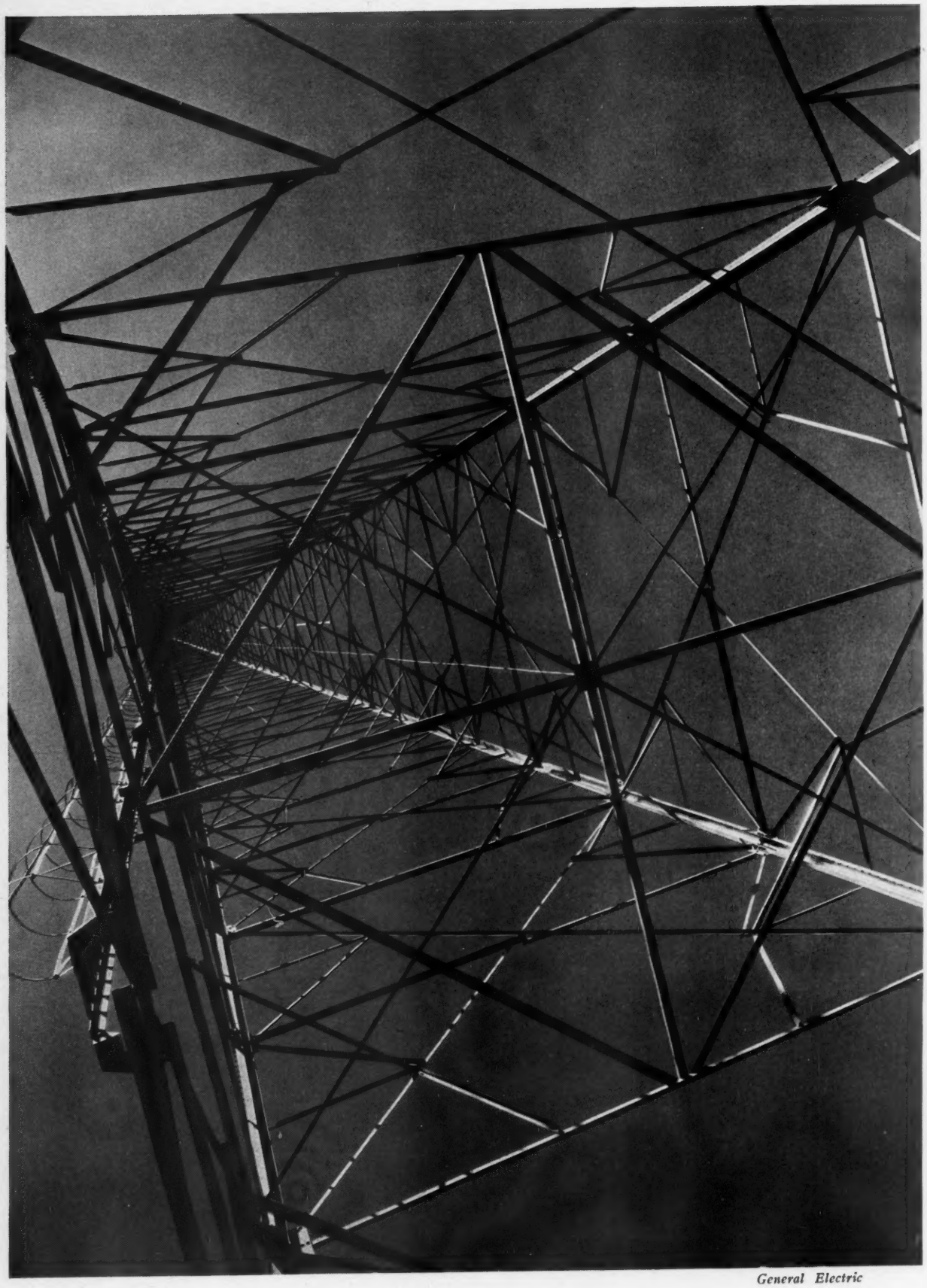


General Electric

SLENDER STRENGTH

Facilitating

ASTRONOMICAL PROGRESS

with Engineering Methods

By BART J. BOK
Assistant Professor of Astronomy
Harvard University

OUR knowledge concerning the structure of the universe has increased rapidly during the past century, and the rate of progress has been particularly fast during the past thirty years. This is probably illustrated most clearly by the fact that it was less than a hundred years ago that the distance of a star was measured for the first time. In fact, exactly a hundred years have elapsed at the time that I write this article since the German astronomer, Bessel, began his accurate observations on stellar parallaxes, which led, in 1838, to the first evaluation of the distance of a star. But even as little as thirty years ago our information on the structure of the universe was still very incomplete. The determinations of stellar parallaxes had not progressed very rapidly, and the total number of well-determined parallaxes amounted at the close of the nineteenth century to hardly more than a hundred. The twentieth century got off on a good start with distinct advances in our knowledge of the structure of the Milky Way system. Kapteyn of Holland found marked regularities in the motions of the stars and worked with the co-operation of several of the world's leading observatories on a systematic plan of analysis to rob our Milky Way of its secrets. Schlesinger, the present director of the Yale Observatory, showed that it would be possible to obtain with our large American telescopes reliable values for the distances of several thousand stars, if the necessary photographic exposures were made with proper care. Pickering at Harvard was compiling huge amounts of data on the distribution of the brightnesses, colors, and spectra of the stars; Campbell at Lick was engaged in studies of the radial velocities of the stars; the Mount Wilson Observatory was about to turn its 60-inch reflector to the sky . . . well briefly, astronomy was definitely off on a big fact-finding spree before the twentieth century was ten years old.

Between 1905 and 1914 it seemed as though the advances in our knowledge of the structure of the stellar system were going to be made largely through studies of trigonometric parallaxes and the motions and spectra of the stars, but before 1920 the plan of attack changed. In the interval between 1914 and 1920 Shapley made his celebrated series of investigations on globular clusters at the Mount Wilson Observatory and succeeded in finding the distances of these very remote objects by a study of the changes in the brightness of certain "variable stars" present in these clusters. The brightness of the stars in question varies periodically, the periods ranging from less than half a day to forty days. Earlier studies by Miss Leavitt at Harvard and by Hertzsprung at Potsdam had shown that the period of the light variation depended only upon the average intrinsic brightness of these variable stars. The photographs of globular clusters taken by Shapley with the Mount Wilson telescopes provided the material for the study of both the periods and average apparent brightnesses of the faint variable stars in these clusters. Miss Leavitt and Hertzsprung had found the values of the average intrinsic brightness for the stars with known periods, and Shapley could therefore find the distances of the clusters in which the variable stars were present.

All globular clusters studied by Shapley were part of our Milky Way, or galactic, system. Shapley's results showed that the size of our stellar system had been grossly underestimated and, most important of all, that the sun was located at a distance of at least 30,000 light

A 120-inch flat mirror will play an important part in the grinding process for the 200-inch mirror. The picture shows the 120-inch disc shortly after it had been cast and still at a high temperature.

The Telescope

years from the center of our galactic system. The first parallax determinations had already shown that our sun was only a star among many and not a particularly bright one at that. Shapley's investigation removed our sun from the central position which it had held in practically all earlier theories and showed that it was off "somewhere" near the edge of our galaxy.

Shapley's work paved the way for further exploration, and a new chapter was begun when, ten years ago, Hubble found a number of variable stars, similar to those studied by Shapley in the globular clusters, in some spiral nebulae. Hubble estimated the distances of the spiral nebulae at values ranging from one million to nearly two hundred million light years and found them to be galaxies in many respects similar to our own galactic system.

The determination of the distances of the globular clusters and spiral nebulae ranks among the major scientific achievements of all ages. For the first time in the history of mankind science was able to present a complete, though admittedly rough, three-dimensional picture of the physical universe. Our estimates may possibly be off by as much as 20 per cent., and our scale of distances may therefore be in need of strengthening, but that is beside the point. We are fortunate to be among the first of human beings to know even approximate values for the distances of *all* observable objects.

The discoveries that have contributed materially to the advance of astronomy are of two different kinds. We shall pass quickly over the type of discovery which is largely a triumph of the mind. Copernicus' theory of our solar system is probably the purest example of such a discovery. Ptolemy and Copernicus had essentially the same observational material at their disposal, but it took the keen mind of Copernicus to realize that the heliocentric theory of our planetary system could give a simpler and more elegant explanation of the facts of observation than the geocentric theory. Instrumental developments played no role in Copernicus' discovery. Newton's theory of gravitation and Einstein's theory of relativity may very well be classified under the same heading.

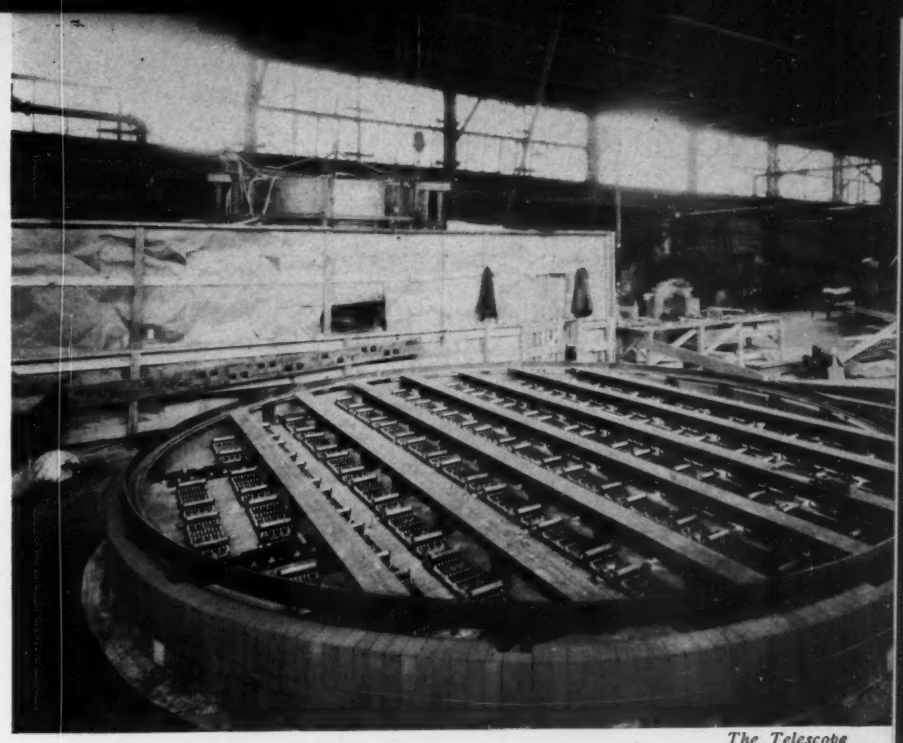
Most of our modern discoveries, however, find their origin in a mastermind, incited either by the possibilities of new instrumental designs, or by the development of a new technique. Tycho Brahe's observations of the positions of the planets offer one of the earliest examples of an important astronomical study in which new instrumental designs played a prominent part. Tycho, who worked during the era just preceding the discovery of the telescope, constructed a group of accurate quadrants that made possible the observation of the position of a star or planet with an error not exceeding one minute of an arc. Tycho was one of the most persistent observers that ever lived and he left at his death an extensive series of observations that held the secrets of the laws of planetary motion. Kepler, who had been closely associated with Tycho for many years, "inherited" Tycho's observations. It was fortunate for the development of science that these valuable observations were to be analyzed by as excellent an astronomer as Kepler; Tycho's observations formed the basis for Kepler's discovery of the three laws of planetary motion. The discovery of Kepler's laws was therefore due to the working together of three factors: (1) The mechanical perfection of Tycho's instruments, (2) Tycho's skill and persistence in observation, (3) Kepler's skill shown in analyzing the great mass of data assembled by Tycho.

With the development of the telescope, spectroscope, and photographic technique, mechanical aids have begun to play a role in the progress of our science which has gradually become more prominent. The 60 and 100-inch telescopes at Mount Wilson put into the hands of the astronomer the most powerful tools that had ever been devised for the aid of man in his attempt to explore and conquer the unknown depths of the universe. But technical skill alone could never have produced the excellent results that have been obtained with these instruments; it took a mastermind to pick from among the many problems of different degrees of usefulness just the one problem that would reveal a deeper and clearer insight into the structure of our galactic system. A study of the variable stars in globular clusters was only one out of the great many problems that might have been studied with these telescopes. But I doubt very much whether any astronomer in the world but Shapley, if given the opportunity to work with the 60 or 100-inch telescope, would have chosen this particular study as providing the most effective line of attack upon the problem of galactic structure. It took a magnificent telescope and a refined photographic technique to provide the proper setting for the attack, but it took Shapley's vision and his everlasting persistence to carry on to a successful ending.

We have limited our discussion here to the problems connected with the structure of the universe, but it would not be difficult to show that similar factors have been responsible for the recent progress along astrophysical lines. The progress of science in general and that of astronomy in particular depend at present to a large extent on the successful co-operation between the men who provide the tools and those who make use of them. Today's astronomer depends on the engineer for his instruments, on both the engineer and physicist for the perfection of his photographic technique, and the astrophysicist has even found it necessary to call upon the physicist to provide him with an effective method of analysis for the data of observation.

The young astronomer of today finds himself starting on a scientific career in a period of rapid progress. The older astronomers have reasons to be proud of their achievements and they have a right to expect that the

The globular clusters are the outposts of our galactic system. This picture shows the great cluster in Hercules, which is one of the most striking objects of its class.



The picture shows the lower section of the annealing kiln for the 200-inch mirror with the heating units and mold frame in their proper places.

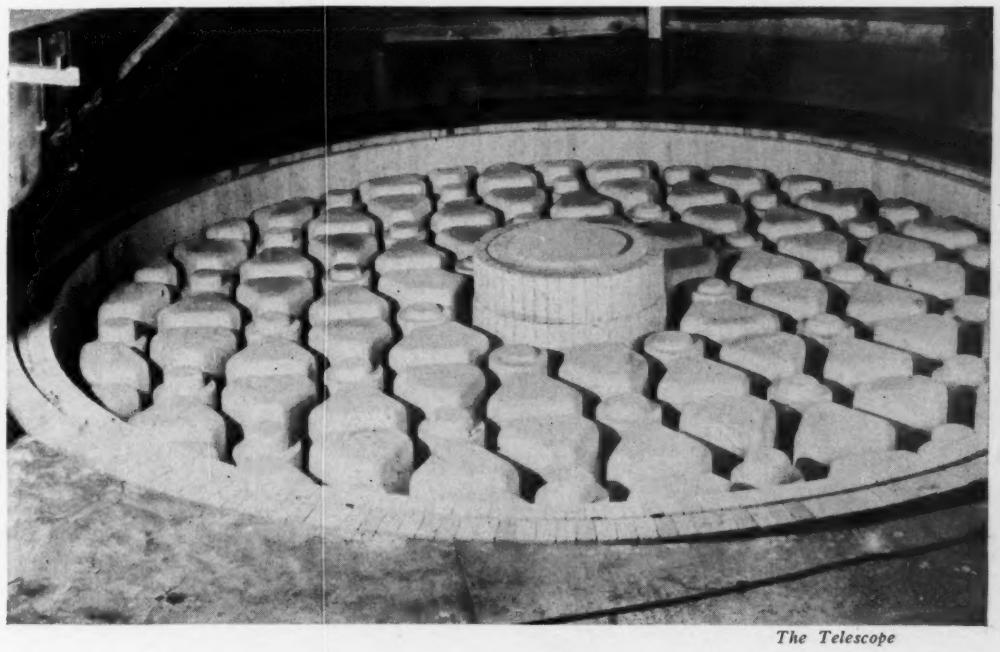
The Telescope

generation to whom they have just taught the secrets of the trade will carry on in the same vigorous spirit that has been characteristic of the progress during the past thirty years. But there can be no doubts that the need for co-operation from the engineer and the physicist will be even greater in the future than it has been in the past, if we wish to keep up the rapid pace of progress that has been set since the beginning of this century. The present article has been written by one who rejoices to be among the young astronomers of today, but who at the same time realizes that there can be only a limited success unless we can be sure of the sympathetic co-operation of a number of young engineers and physicists.

A discussion of some of the plans that have been made in connection with the building of the 200-inch telescope gives us probably the best illustration of the engineering problems of the astronomer. The first problem that had to be solved was that of the pouring of a satisfactory 200-inch disk. There was first of all the choice of the material from which the disk was to be made. Astronomers have to be rather fussy on this point since a 200-inch mirror of ordinary glass, with its relatively large coefficient of expansion, would be of no use at all to astronomers. After several years of experiment a new kind of pyrex glass, which is, however, essentially of the same composition as the pyrex from which the nursing bottles are made, was developed, and last January a satisfactory 200-inch disk was poured at the Corning glass works in Corning, N. Y. The making of the 200-inch disk is, however, only one of the difficulties that has to be overcome; in the opinion of many the most difficult step in the development will come when the grinding of the rough disk is attempted. Unexpected difficulties are apt to come up in any part of the grinding process, especially since the Californian astronomers have decided to increase the light-gathering power of the instrument by giving a higher degree of curvature to the surface than has usually been the rule for large telescope mirrors.

The size and quality of the mirror is only one of the factors which contribute to the effectiveness of a large telescope. An excellent mirror is hardly of any use for scientific investigation unless it is properly mounted. The astronomer desires for his telescope a mounting which is as free from flexure troubles as it can possibly be and which at the same time permits immediate adjustment to any desired portion of the sky. The mirror should rest in the telescope tube without any chance of slipping and with the least possible amount of strain at whatever angle the astronomer may wish to tilt the mirror during the observations. The building of the mounting for a large telescope is a delicate and difficult engineering project in itself, and the astrono-

(*Continued on page 118*)



The mold for the 200-inch disk. The rib structure for the back of the mirror has been chosen, in order to reduce the weight of the mirror without impairing its rigidity. The large central core will produce a 40-inch hole in the mirror for the Cassegrain mounting.

The Telescope

By Symplifying Manufacturing

SYNTHETIC PLASTICS

Rival Metals

By JAMES D. McLEAN, '37
Massachusetts Institute of Technology

WHEN a prehistoric man discovered that a certain kind of clay could be molded to form utensils and dried in the sun, the first molded plastic was originated. The first clay vessels were very fragile, but, by accident, the ancient men found that fire made the clay harder and more durable. The porous nature of the clay, however, made the utensils unsuited for cooking and heating liquids. A subsequent discovery that crude salt, thrown in the fire used for "burning" the pottery, would make a hard, nonporous surface was one of great importance in the development of ceramics. Ancient glazed pottery, thousands of years old, has been found in good condition and perfectly preserved. The art of pottery-making has progressed through the centuries, and still the original molding substance, clay, is in use today.

The art of molding plastics commercially for the production of parts for industrial purposes is not new. In the past celluloid, hard rubber, shellac, and other plastics have been used; but they have been largely replaced by new synthetic resinoids, phenol compounds, and organic materials. Some of the disadvantages of the former compounds are: low mechanical and dielectric strength, inflammability, limited color range, disagreeable odor and taste, and softening at high temperatures. The newer compounds, however, have higher resistance to heat and arcs, lower cost, greater variety of colors, chemical inertness, and a good finish.

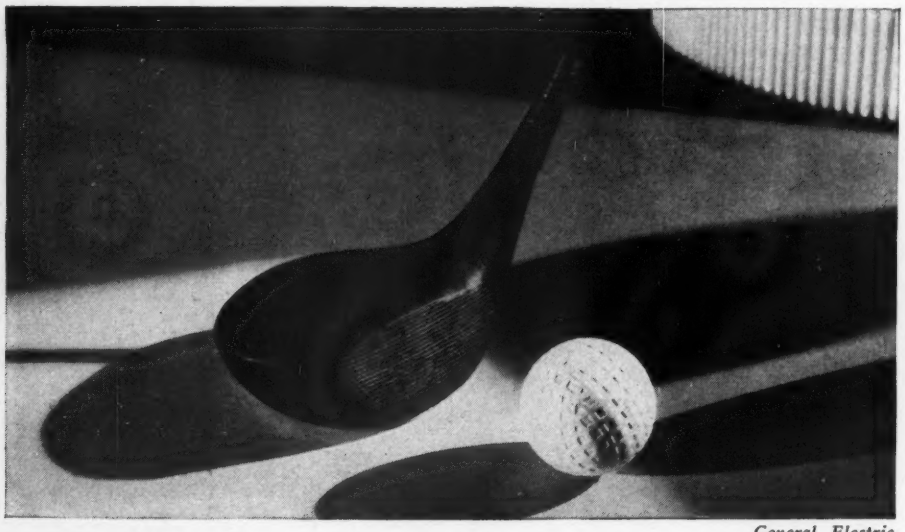
Plastics can be divided into several groups: synthetic resins that are roughly cast and then machined, hot and cold molded compounds, impact molded compounds, and laminated products with shellac, resinoid, asphalt, or pitch binders. Trade names and formulae of plastic compounds are as numerous as the companies that manufacture them. Cast synthetic resins, such as "Catalin" and "Marblette" are furnished in rods, sheets, tubes, or special castings, all of which may be ground turned, and polished. "Catalin" in its original state is a liquid, similar in consistency and color to golden clear honey. It is composed of a number of highly refined chemicals, the principal of which are phenol and formaldehyde. Phenol, commonly known as carbolic acid, is a by-product of the manufacture of coke, and formaldehyde, a gas, is formed by the partial oxidation of methyl alcohol. When heated, these compounds combine to form the primary, or "A" type, synthetic resin. The primary product may then be heated, poured into lead molds, and allowed to cure in an oven for a definite period of time. After the solid is removed from the molds it is ready to be machined and shaped into finished products.

In the manufacture of "Bakelite" the primary resinoid compound is converted from a material of low melting point and high solubility to a hard, strong, insoluble, and infusible resinoid by the application of heat and pressure. This change of properties brought about by heat is called polymerization by the chemist. The heat causes the transformation, and the pressure prevents distortion and cracking which might be caused by the rapid condensation.

The resulting resinoid has a tensile strength of 7000 pounds per square inch of surface area and a specific gravity of 1.27. It will not melt but begins to carbonize at about 570 degrees Fahrenheit. It is not affected by ordinary solvents, acids, oils, and most other reagents. The resinoid may be made in practically any color or mottled effect. It is soft enough to be easily drilled, turned, sawed, ground, threaded or tapped, embossed, and highly polished.

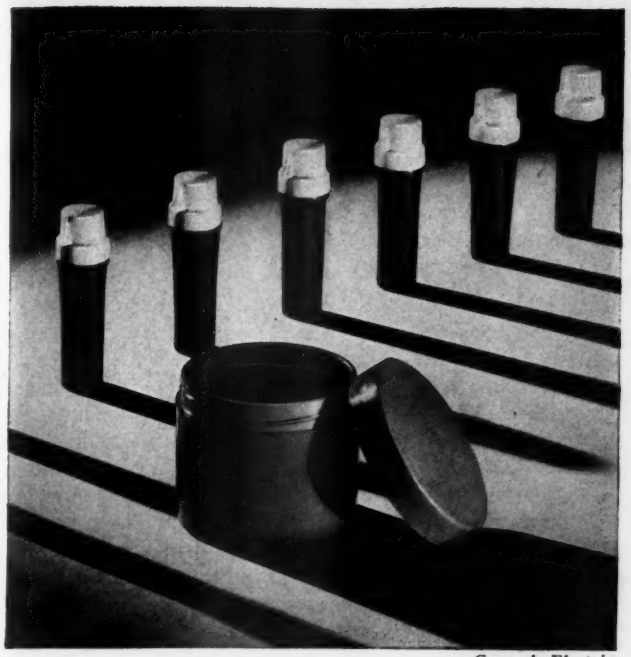
Quite different from the cast synthetic resins are the ground primary resinoids which are mixed with a filler and sold in the form of a powder. In this form they are molded under high temperature and pressure to form the polymerized resinoid. The resinoid fuses and reacts chemically with the filler, which may be wood flour, mica, asbestos, cellulose, or other materials, either organic or inorganic.

The properties of the so-called hot-molded resinoid compounds depend to a great extent on the filler used. Wood flour gives a high finish and light weight; mica produces high heat and electrical resistance: asbestos gives a very great heat resistance; and cellulose makes the product mechanically tough. The hot-molded products, however, soften or carbonize at extremely high temperatures. They are non-resistant to electrical arcs and require expensive molds.



General Electric

Molded golf-club heads provide unusual strength, toughness, and resilience.



General Electric

Lipstick containers and cosmetic jars are only two of many plastic products.

Cold-molding is done at ordinary temperatures, the compound being rendered plastic by water, some organic solvent, or vegetable oil. The material is molded under pressure, but without heat, and then is baked or treated with steam to harden it. This process converts the parts to stone-like masses by a chemical reaction. The parts are baked in electric ovens for periods varying from twenty-four hours to one week.

Products made by the cold-molded process have a higher resistance to heat and arcs because of inorganic ingredients. The molds are cheap and fewer are needed because no time is required to cure the products while in the molds. This type of product, however, has a low mechanical and dielectric strength. The finish is often poor and the colors are usually limited to black or brown. Intricate parts cannot be molded easily and the material cannot be machined satisfactorily. Where threading is required metal inserts must be used.

Molded products often simplify the manufacture of an article which formerly required a number of machining and finishing operations. The molded plastic product comes from the mold with all surfaces, holes, and projections accurate in size and shape. Holes, screw threads, designs, figures, and letters are accurate in every detail and the finish is hard, smooth, and does not require polishing.

Quantity production is essential in the manufacture of molded plastic products to take the place of metal or porcelain articles. Molds and machinery are expensive and a sufficient volume of products must be manufactured to offset this cost. The various types of equipment for machining operations are done away with, but heavy hydraulic presses for molding plastics are required. The General Electric Company produces 160,000,000 molded parts a year at one plant alone. The tremendous output offsets the initial cost of the machinery. The use of multiple-cavity molds increases the output of each molding cycle. Thus, from a single mold a gross of caps for tooth paste tubes can be produced in a single operation.

Another type of molded product is laminated material. The definition of laminated is "consisting of, or arranged in, layers or thin plates, one upon the other." In the manufacture of "Bakelite Laminated" the same unpolymerized resinoid is again employed. The primary, or "A," resinoid is dissolved in alcohol to form a varnish. The varnish is then used to impregnate the laminating fabric, which is either paper or cloth. The fabric is dipped into tanks of the resinoid varnish and then dried, evaporating the solvent and leaving an even coating of primary resinoid. A large number of sheets of impregnated fabric are superimposed and placed in a hydraulic press. Under the action of heat and pressure the mass of resinoid-impregnated layers is polymerized and transformed into a hard, dense plate which cannot be resoftened by heat, is non-hygroscopic, and possesses unusual mechanical and dielectric properties.

Several types of laminating fabric are used, including Kraft paper, rag paper, linen, canvas, and asbestos fabrics. Paper gives a resiliency to the material which enables it to be punched and riveted easily, without cracking or chipping. It also produces high electric and radio frequency insulating properties. Linen fabric and airplane cloth, closely woven, make a laminated product of the closest grain and the greatest possible toughness. The price of linen, however, makes this type quite expensive. Canvas is used where the maximum shock resistance is required. Gears can be fabricated from laminated canvas which will successfully withstand the stress of driving heavy machinery and still be noiseless and long wearing. Tubes, rods, and sheets are manufactured from the laminated resinoid compounds.

In the last few years the plastics industry has developed tremendously. Today there are hundreds of uses for every type of molding compound. Millions of articles are manufactured every year, ranging from Christmas tree light sockets to beer steins and radio cabinets. Plastic products have been universally adopted wherever an attractive, durable article has been required. The field of plastics is large and varied, and only a few of the forms and uses have been described here.

General Electric

Resistance to arcing distinguishes molded distributor head.

Controlling Weather by

AIR CONDITIONING

to Increase Comfort

By A. W. RUFF and A. B. NEWTON, '31
York Ice Machinery Corporation

THE processes of living in our present age have so rearranged themselves during the past generation that we now find more time for recreation and home life. Also, the causes of ill health and discomfort are becoming more fully understood so that science has actually been challenged to produce a new type of home and improved living surroundings. An immense program of rearrangement and creation has been under way for several years, and the American public has already been presented with certain accomplishments resulting from this investment of ingenuity and time. The three predominant offerings are home arrangement and construction, means of transportation, and improvements in health.

A simple definition of comfort air conditioning might be stated as the duty of making people more comfortable. From an engineering standpoint, it represents the correction of factors in the surrounding atmosphere which are unsuited to our physical beings, by a treatment which is not detrimental to mental reactions. Each of us unconsciously acclimates himself to his surroundings. Consequently, sudden changes of weather often upset us physically. It is frequently difficult to suit a person exactly, at first, with comfort air conditioning for this very reason, but as soon as the novelty wears off and his body relaxes to the more suitable surroundings, considerable benefit is realized.

The dry bulb temperature, such as we read on a chemical thermometer, has usually been considered as the measure of human comfort. However, comparatively recent studies have proven that humidity, or moisture content, may be even more reliable in this respect. Other factors of importance are air motion, fresh air for odor elimination, and filters to purify the air from dust, lint, and pollen given off by various forms of plant life. Consideration is also given to noise, ionic content of the air, and appearance of the apparatus.

The comfort chart as exhibited in Fig. A is based on scientific investigation by several leading societies and universities. It represents the average reaction of an extremely varied group of human beings and hence is the best guide now available as to what our equipment must be designed to do.

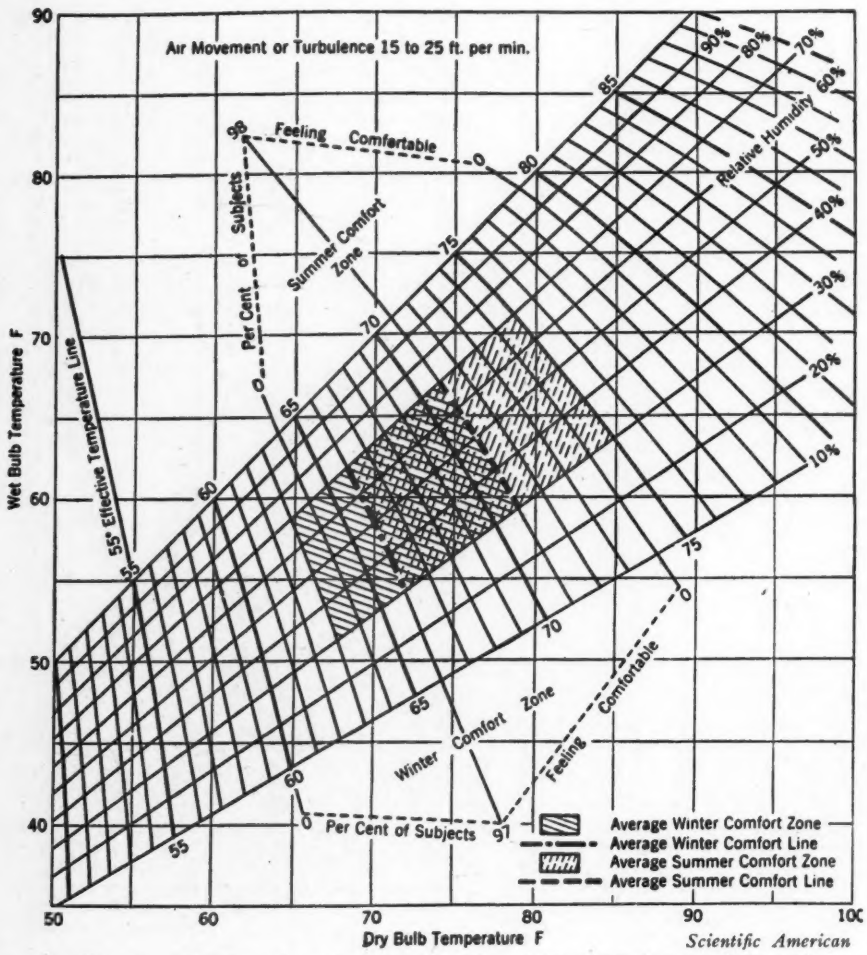


Fig. A.— Comfort chart for air velocities of 15 to 25 F. P. M. (still air).

In the summer time sensible heat flows into a cooled room from two sources—the warmer atmosphere outside the room and warmer objects in the room, including human beings. The amount of water vapor in the room air is increased by evaporation of moisture from the skin and from cooking, as well as by infiltration of outside air. To produce comfort, then, it is not only necessary to maintain a proper temperature, as shown on the common dry thermometer, but also we must continually remove the excess water vapor from the air.

This water vapor, or steam, in the air exerts a pressure of its own just as any gas does. The barometer measures the sum of the air pressure and the water vapor pressure, and the ratio of the latter to the total is equal to the percentage by volume of the water vapor present. We are all familiar with the fact that for each pressure at which water exists, there is a definite temperature at which it will boil if we add heat, or the vapor will condense if we remove heat. In a mixture of air and water vapor this temperature is called the dew-point. Thus, by passing air over a surface maintained at a temperature below its dew-point, water will be condensed on the surface. This water will have a temperature approximately equal to

the surface on which it is condensed; therefore, its vapor pressure is less than that of the water vapor in the main body of air, and the difference in vapor pressure between the two points causes a movement of the water molecules toward the cold surface. This explains why it is not necessary to cool the entire body of air below the dew-point to cause condensation. Furthermore, the rate of travel of the molecules is directly proportional to the difference of vapor pressure in the main body and at the cooled face, other factors remaining constant. Thus by controlling the temperature of a refrigerant evaporator we can control the amount of moisture picked up.

When a finned surface evaporator is used, the problem of calculating results is a bit more complicated than with bare pipes, since the average fin temperature may be ten to twenty degrees above the refrigerant temperature, and this difference varies with the load on the coil.

Fig. B shows the principle of the refrigeration cycle used to cool and dehumidify. The compressor maintains the pressure of the refrigerant in the evaporator to correspond to the boiling point desired. Air is forced over the evaporator and heat flows from the air to the refrigerant, as shown by the arrows. The gas discharges from the compressor at a pressure corresponding to the condensing temperature, which must be high enough so that the latent heat of condensation can flow into the outside air or the cooling water. The minimum heat rejected to the cooling medium is the heat removed from the room plus the work of compression. It is always necessary to remove this rejected heat from the room by some external medium, or the net effect would be to add the heat of compression to the room.

Actually, we are "pumping" heat from a low temperature level to a higher one with the help of mechanical energy. As much as six to ten times as much heat may be "pumped" as is represented by the work done by the compressor. During the heating season it is possible to place the evaporator outside and the condenser inside. Set up in this manner, the equipment will "pump" heat from the colder outdoors into the warm room. This is called the reverse cycle, also shown in Fig. B. Unfortunately, with a given compressor, the heating capacity of the reversed cycle falls off rapidly as the outside temperature falls; thus the application is at present limited to localities having relatively mild winters.

Two types of conditioning units are available for comfort cooling—water spray, and cooled surface units. The former is at present applicable only in central system installations, and lacks the flexibility inherent in the cooled surface system.

The water spray, or air washer, type consists of a chamber in which a fine spray of cooled water is intimately mixed with air to be circulated through the conditioned rooms. The amount of cooling and dehumidification may be governed by the water temperature and air quantity. The fineness of the spray has much to do with the efficiency of the unit. A means must be provided for removing water entrained in the air. Periodically the unit must be shut down for cleaning, as the dust and dirt removed from the air is collected in the bottom of the chamber. At present this system is seldom considered for small comfort cooling installations.

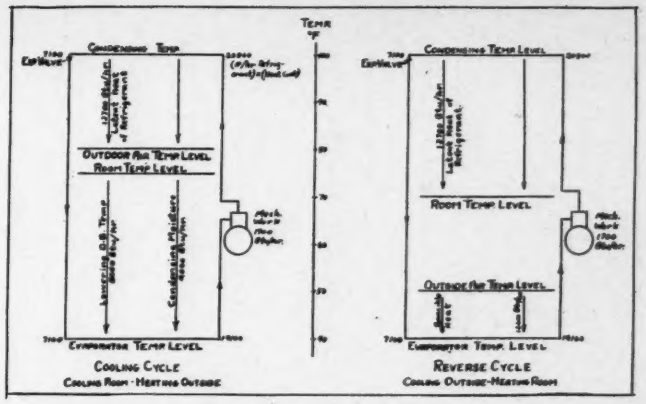


Fig. B.

The type of system in which uncooled city water is sprayed into circulated air is probably an outgrowth of the air washer idea. To be effective in producing comfort, city water must be available well below the dew-point of the average air to be conditioned. This is the case only in very few localities, and, since the temperature of the cooling water is not controllable, it is very difficult to maintain scientifically accurate comfort conditions with the city water alone.

Most manufacturers in the industry have concentrated on the cooled surface unit. Its great flexibility in installation, its ease of control, and the fact that it can be manufactured in "package" form, suit it ideally to the small and medium size comfort cooling problems. Two applications, each requiring its own specialized equipment, must be considered—the unit system, and the central system.

Any application in which the air to be conditioned is not removed from the room containing the unit may be classified as a unit system. A unit conditioner may be self-contained, *i.e.*, the compressor, condenser, and cooling coil all located in the same cabinet, or the system may be split, having the compressor and condenser remotely placed, and the refrigerant, cooled water or brine, circulated through the cooling unit.

The essentials of a unit designed for the latter application are: a cooling coil, usually of the finned type; a fan to circulate room air over the coil and discharge the air back into the room at a velocity high enough

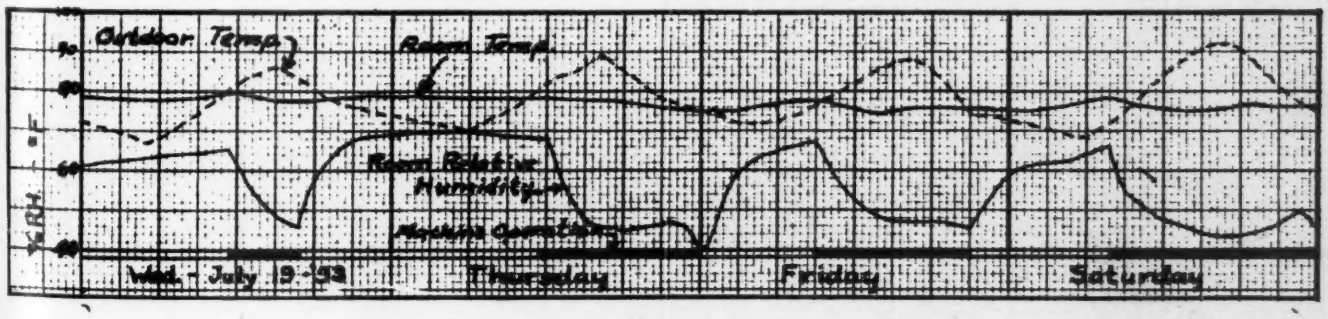


Fig. C.

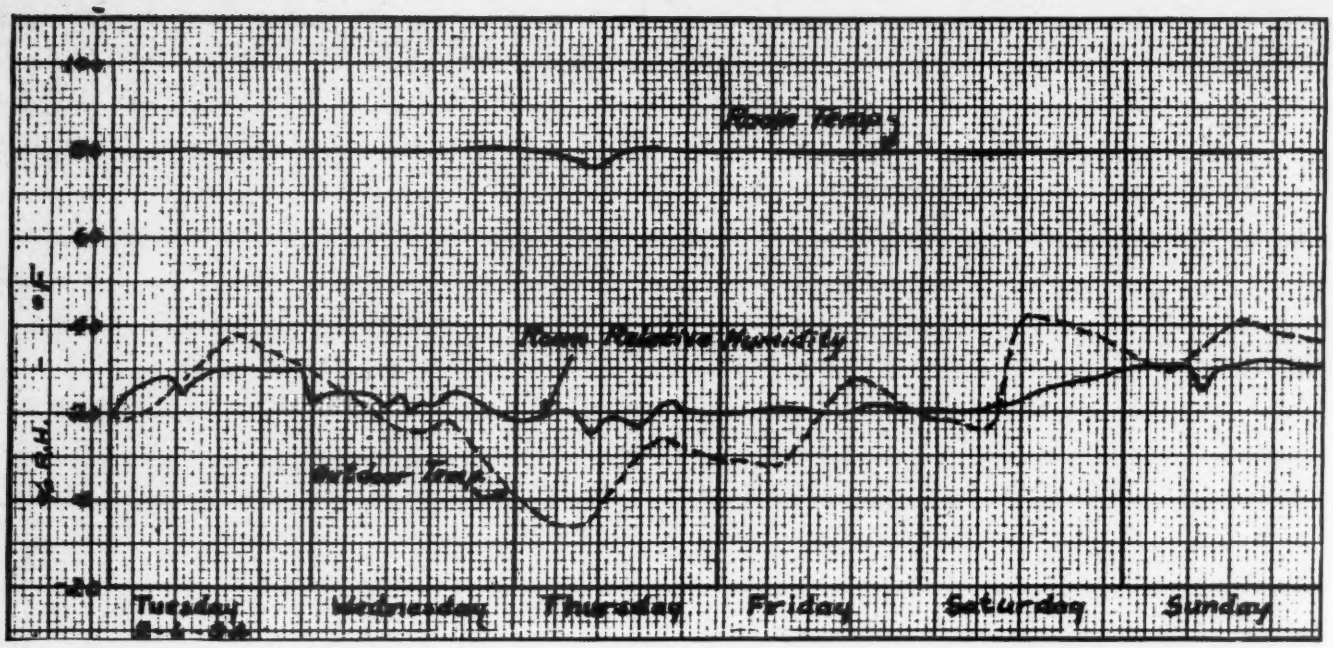


Fig. D.

to give good distribution; a filter in the air stream; a drip-pan for collecting the moisture removed from the air; and a decorative casing containing a discharge grille to direct the cooled air. If the unit is to be a year-around conditioner a heating coil and humidifier spray must also be provided.

In many units an electric fan circulates air over the cooling coil, which acts as a refrigerant evaporator. City water or other water may be used if available at a low enough temperature. The units require connections to the cooling medium, electric power for the fan motor, and a drain connection for the condensate. If the unit is also to be used for heating, steam or hot water connections and humidifier water must be supplied. When placed under a window, a small duct applied at the rear of the unit enables the fan to draw in from ten to thirty per cent. of fresh air.

The self-contained unit requires fewer external connections. Many laymen consider that a self-contained comfort cooler similar to a radio should be available. If developed, it could be set in a room in any convenient location, plugged into the nearest electrical outlet, and moved about whenever or wherever it suited the whims of its owner. As we have shown above, this ideal unit cannot quite be realized, since it is always necessary to remove from the room the heat and condensate collected by the unit. At present, we obviously cannot remove this heat through the electrical connection.

Either air or water may be used for this purpose. An air-cooled unit must be placed in such a manner that outside air is drawn through the unit, over the compressor and condenser, and then discharged to the outside again. The amount of outside air circulated varies from three to six times the amount of room air put through the cooling coil in the unit. Usually the casing is so designed that, when the conditioner is placed under a window which is slightly raised, short ducts may be run through the opening to provide the outside air supply. The water condensed out of the air in the room may be removed by the outside air discharge. A fresh air supply for the room is a simple problem in this type of equipment.

A self-contained unit of this type is quite portable. By providing it with proper adjustments it can be moved to different rooms on a given floor in a home or office, but it would be too heavy to take up and down stairs without an elevator. All it requires is an electrical connection and a window or other outdoor opening through which to throw away the heat removed from the room.

A water-cooled self-contained unit is somewhat smaller than the air-cooled unit of like capacity, and need not be placed under a window. It requires water and drain connections, and hence once installed, is not often moved. In large water-cooled self-contained units, such as might be used in a business establishment, the

(*Continued on page 116*)

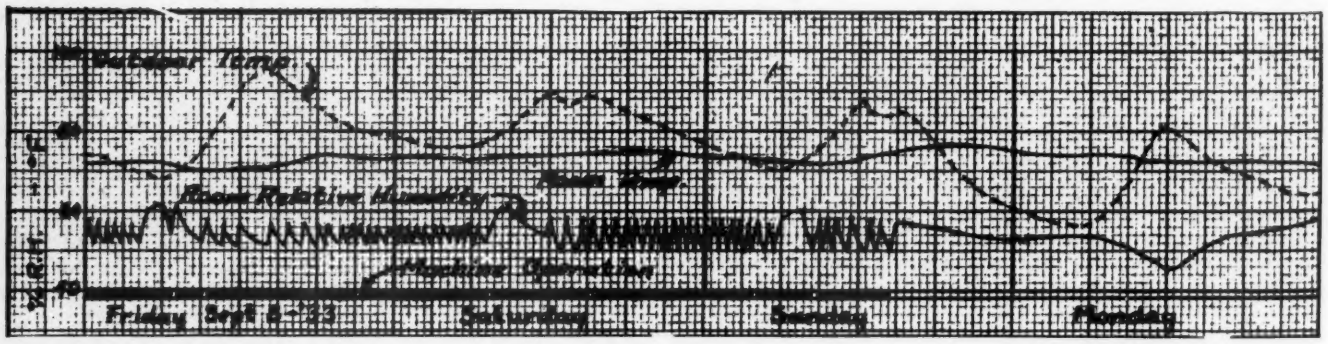


Fig. E.

Recording Valuable Facts of

NAVAL ARCHITECTURE

—SAMUEL PEPYS' DIARY

By JAMES R. JACK
Professor of Naval Architecture
Massachusetts Institute of Technology

HISTORY has been uncharitably defined as the science of inaccuracy and misrepresentations, and indeed there have been few, if any, historians who have written without prejudice, national, political or religious, of the events which they desired to describe. In most cases they have told of things not as they were, but as they wished they had been. To this accusation the historian generally replies by throwing the blame on the compilers of the documents and other data from which he has worked, and often with considerable justification. In one outstanding case, however, this accusation can not be made, for if ever there was a true human document it is the diary which Pepys wrote between 1660 and 1669. It must have been his intention to keep this diary absolutely secret from the world until long after he was dead, as he wrote it in Shelton's shorthand, which, however, he elaborated himself in many ways, using several foreign languages as well as English in order the better to keep up his confessions. It is indeed well that he did so as many of these same confessions reflect no credit whatever on his character, but the very fact that he has been so very frank with himself testifies to the trustworthiness of his record regarding other people and the times in which he lived.

Coming of a good family which, however, had hit bad times, he was very poorly brought up, but he was able to enter Cambridge University at the age of seventeen, beginning at Trinity Hall, and a year later transferring to Magdalene where he took his B. A. degree at the age of twenty-one. Six years later he took the M. A. degree. When twenty-two years of age, although without any income, he married, his wife being only fifteen. She was a daughter of a Huguenot family then living in England. Fortunately his relative, Edward Montagu, later Earl of Sandwich, engaged Pepys as a clerk to one of the tellers of the Exchequer, and Montagu took him with him to Holland when the end of the Commonwealth brought the restoration of Charles II to the throne. He was now appointed clerk of the Acts to the Navy Office, but it is said that at that time he knew so little about clerking that he had to learn the multiplication table before taking up his duties. This seems remarkable in a man with a Master of Arts degree, but the late Dr. Eliot stated that when he went to Harvard as president most of the medical examinations were oral as the candidates wrote too poorly for all their examinations to be in writing. Perhaps this is not so surprising when we consider that even today a doctor's prescription is rarely legible except to a trained druggist. Here for the first time we see the tremendous energy that Pepys possessed and the capacity for concentrated study which enabled him to pass from one responsibility to another, in each case without having the necessary preparation for that responsibility, but devoting himself enthusiastically to the work until he became highly efficient.

During the naval war with Holland most of the supply department was in his hands in addition to his own work, and when, in the middle of that war, the great plague of London broke out, he was deserted by many of his staff, but he stuck to his job saying that as others of the king's servants faced the dangers of war he would face those of disease. At that time the English Navy was in a very bad way. The king, Charles II, had diverted much of the ship money towards his own very questionable ends. His brother, the Duke of York, was Lord High Admiral, and whatever his faults may have been—and they were many—he was at least anxious to do the best he could for the Navy, and so Pepys became very intimate with him.

After the war the parliamentary inquiry into the state of the Navy was begun and Pepys was put up to make the defense, which he did brilliantly. For the Duke of York Pepys drew up two important documents, *viz.*, "The Duke's Reflections on the Several Members of the Navy Board's Duty," and "The Duke's Answer to Their Several Excuses." His success led him to stand for Parliament in 1669, but his wife's death interfered with his campaign and he was defeated. Four years later he was elected, but the election was challenged and he lost his seat.

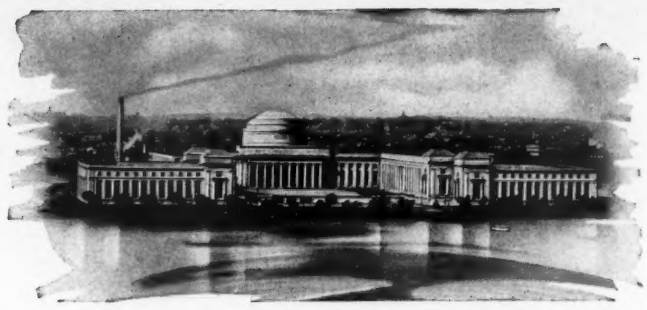
The moral standard of those days was exceedingly low and all manner of graft was rampant. That Pepys profited by his official position to some extent is probable, but certainly he was more inclined to appropriate plans, documents, and models than actual cash. Indeed, being suspicious of the timber contracts for the Navy he actually went out to the forests himself to superintend the measurement work and qualified himself as a timber measurer so that he detected serious frauds on his Majesty which were promptly stopped.

The diary was begun at the age of twenty-seven, and he rarely allowed it to remain very far behind, working often until early morning by candlelight in order that his record might be made up while fresh in his mind. The effect of this on his eyesight was unfortunate, as it was the failing eyesight which caused him to cease his entries in the world famous diary. Having no family of his own he bequeathed his possessions to his nephew, John Jackson, son of his sister—and afterwards (in 1724) they were transferred to his college, Magdalene, in Cambridge, where they are now preserved in a special building. Many visitors come to the college every year to see some of the valuable material which Pepys collected. The diary is a great source of interest and the part usually shown to visitors is the description of Charles II's escape after the Battle of Worcester when he hid in an oak from Cromwell's men, as that is an incident with which everyone is familiar, and the memory of which is perpetuated in the British Navy by a ship named Royal Oak. This account was taken down by Pepys from the king's own words.

For many years after the documents were deposited in Cambridge comparatively little interest was taken in them, but the publication of Evelyn's Diary in 1818 suggested to the then master of Magdalene that Pepy's

(Continued on page 115)

THE TECH ENGINEERING NEWS



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EDITORIALS

FACTS VS. OPINIONS

THE distinction between the guessers, who jump to conclusions, and the analytical reasoners, who want facts before action, is a difference which can be traced all the way from reptiles to men.

Consider the fresh water turtle. Astray on a summer's afternoon you have seen him sunning himself on a log, but on hearing your approach off he goes into the water. With a persistency at once comical and tragic he will follow this behavior pattern. Capture him; set him down atop a beam, a limb, or a window sill, and —no matter how matchless your courtesy to him—off he goes without the least hesitation no matter whether it is two feet or two hundred feet to the rocky ledge below. Blindfold him and the same thing happens.

Not so his landlubber cousin, the tortoise. This reptile invariably looks before he leaps. He obeys no vagrant impulse to jump. Blindfold him and he will cautiously set about removing the obstruction before he does anything else.

Why? Because the tortoise has a cortical layer at the base of his brain which the turtle entirely lacks. Indeed the tortoise is the lowest form of animal to possess the inestimable boon of such a layer, the function of which is to make him hesitate before he acts impulsively.

You, too, have a cortical layer at the base of your brain. How is it working?

F. ALEXANDER MAGOUN,
Professor of Humanics.

HIGH SCHOOL CURRICULA

THE success of any democracy or republic is largely dependent on the intelligence of its electorate, an intelligent electorate being defined as one whose members are actively interested in the problems of municipal, state, and national government and have at least a general knowledge of those problems and the conditions from which they arise. Such an electoral intelligence would not long permit the existence of the stupid graft and corruption which today are still present in so many branches of the American government.

Contrasted with the desirable condition of having an intelligently interested electorate is the present-day political apathy of the American people. One of the immediate causes of that apathy is the lack of political and economic training which the American public receives. The consequent ignorance of the average citizen forces him to swallow in their entirety the screaming political headlines of the typical American newspaper; his ignorance prevents him from separating that part

(Continued on page 120)

RESEARCH IN REVIEW

COURSE V — Chemistry

THE era of the generation of low-pressure steam for power ended about a decade ago when the program for the comprehensive investigation of the properties of water in the form of steam was initiated by the American Society of Mechanical Engineers. The program referred to was divided into three parts. Some of the work was done at the Harvard Engineering School. Certain heat measurements were made at the United States Bureau of Standards. Here at the Massachusetts Institute of Technology the pressure-volume-temperature relationships of steam were studied under the direction of Professor Frederick G. Keyes, head of the Department of Chemistry.

For the past fourteen years the work has gone on and many practical developments have resulted. As rapidly as data became available, steam turbines were designed to operate at higher temperatures and pressures than ever before attempted. The greater efficiency of these new turbines has resulted in economies having a marked influence in reducing the cost of producing power. At the present time the design of higher superheat turbines capable of operating at still higher pressures is not being reduced to practice. It is safe to predict, however, that with the perfection of heat resisting alloys, the designs will be executed with further savings in the cost of power production.

The increased knowledge of the properties of steam is due not alone to the scientific investigations going on in the United States. It is, in fact, the result of a great international co-operation. Important measurements have been in progress in England, in Germany, and in Czechoslovakia since the American program began. A common impulse on the part of the investigators to reach a world-wide agreement promoted the first International Conference on the properties of steam, held in London in 1929. It was followed by a second conference in Berlin in 1930. Finally a third International Conference was held in the United States this autumn, from September seventeenth to twenty-second. These latest meetings took place in Washington, D. C., at the Massachusetts Institute of Technology, and in New York City. The researches of the different investigators were considered in detail and a Skeleton Table of values which were agreed upon for the properties of steam was prepared. Agreement regarding certain questions of units was also reached. Any future steam tables containing values for the properties of steam, coming within certain limits specified in the International Skeleton Table, will be known as an International Table and will be used in official tests of turbine performance. In this way. disputes concerning guarantees and other questions arising in the generation of steam at very high pressures and temperatures can be avoided and international amity in at least one field can be improved. The Fourth Conference on Steam Tables will be held in Prague not earlier than September, 1936.

Among the subjects being investigated at present in the Research Laboratory of Inorganic Chemistry, the following may be mentioned:

The preparation of halogen substitution products of the boron hydrides, in the course of a general study of boron chain compounds. Dr. E. Lee Gamble, in the course of this work, has constructed an elaborate apparatus for carrying out the fractionation of volatile compounds, based upon that employed by A. Stock in his researches upon the hydrides of silicon and boron.

Professor R. C. Young is continuing his study of the chemistry of thorium with a view toward the preparation of lower valence compounds. Incidental to this work he has determined the composition and the decomposition pressures of the ammines of thorium bromide. A check-up is also being made of the halides of rhenium, concerning which the literature is conflicting.

COURSE VI — Electrical Engineering

IN searching for the cause of any derangement in the human mechanism a physician relies primarily upon a physicial examination, that is, upon the estimation or measurement of certain physical quantities. Indeed the clinical thermometer has become almost symbolic of the medical profession. Although living tissue exhibits many electrical properties so conspicuously that the present science of electricity may be said to have originated in the laboratory of an anatomist, electrical quantities are rarely included among clinical measurements. It seems certain, however, that quantitative measurements of the electrical constants of living tissue should yield information of their condition quite as pertinent as that obtained by the thermometer.

On this hypothesis the Department of Electrical Engineering has undertaken a study of living tissue considered as an electrical system. Already methods for measuring the impedance of internal body tissues have been worked out in a form suitable for clinical use. These methods are in use at the Massachusetts General Hospital and elsewhere for the collection of statistical data regarding any possible correlation between the electrical constants and deviations from normal conditions. Already there is evidence indicating a relation between the impedance of the internal tissues of the human body and the condition of the thyroid gland.

Simultaneously with the above statistical study there is under way an investigation of the fundamental properties and behavior of living tissues as revealed by purely electrical measurements.

COURSE XII — Geology

PROFESSOR MORRIS travelled in Wyoming this summer, and studied lava flows in their relation to the deeper molten rocks which invade them, and the surface rocks over which they flow. He saw invading rocks which dissolved the lavas; and thick lavas which retained their heat and juices so long that they were able to dissolve and digest other lavas, and even sandstones and shales. These rocks will now be studied petrographically, and compared with similar effects which his students in the Department of Geology are finding in Eastern Massachusetts; for our Boston area was once not unlike the Yellowstone Park.

This fall Professor Mead from the University of Wisconsin has been made head of the Department of Geology at the Institute and under his able leadership several research projects will be undertaken this year.

ENGINEERING DIGEST

INTOXICATED TADPOLES

ALCOHOL when taken in small amounts does little harm to the nerves, even if taken over a long period of time. But the amount of alcohol consumed during a drinking party may injure the nerves irreparably. These facts have been recently added to the scientific knowledge of the effect of alcohol on the body by Professor Carl C. Speidel of the University of Virginia, a young scientist who has been studying the behavior of nerves in living organisms.

By the patient microscopical study of the nerves in transparent tail fins of alcoholically intoxicated tadpoles, Professor Speidel has answered the question long puzzling scientists of what actually happens to nerve structure during inebriation.

Dr. Speidel observed that under severe intoxication the "myelin sheath," which he described as being a fatty covering of the form of segments arranged somewhat like a string of sausages, whose function it was to protect, insulate, and nourish the nerve fiber, became separated from the nerve axis. Degeneration of the nerve followed. Swellings and undulating movements appeared on the sheath, the nerve axis assumed an irregular wavy course, and myelin globules and ovords were formed.

Professor Speidel commented that, if the theory were true that the surface joining the myelin sheath and nerve axis served to conduct nervous impulses, his work would explain that the drunken man cannot think fast, cannot walk or talk straight, and cannot use his senses acutely, because the myelin sheath has become separated from the axis of certain of his nerves. (*Science News Letter*, September 15, 1934.)—W. B.

CHROMIUM STEELS

CHROMIUM steels were the first steel alloys to be made. Hardness was their most valuable property, and it led to their further development which culminated in stainless steels.

Between the "stainless" class and the very low chromium alloys are about three groups whose chromium content ranges between 0.4 and 7.0 per cent. Chief among those whose chromium content is between 0.4 and 0.6 per cent. is cromansil which also contains 1.1 to 1.3 per cent. manganese and 0.6 to 0.8 per cent. silicon (whence the alloy's name). Cromansil possesses physical properties which are superior to those of plain carbon steels and at the same time requires no heat treatment. In addition to an increased ductility, cromansil retains its toughness at low temperatures—an increasingly important property today.

Cromansil rivets exhibit a greater strength than any other variety and do not harden after riveting. At the same time, cromansil joints and plates show an equally favorable strength so that the combination of plates and rivets offers a highly satisfactory fabrication.

Plain chromium steels of 1 to 3 per cent. chromium content respond to a simple heat treatment such as air hardening which is similar to a liquid quench with other steels. The resistance to corrosion has been found to increase with the chromium content. This type of alloy is particularly suitable for wear resistance purposes like rock crushers, dredge teeth, and railroad rails.

Several years ago an oil refinery wanted to obtain a corrosion resistant steel intermediate between the plain carbon and stainless steels and a 4 to 6 per cent. chromium steel was found most satisfactory. With this class air hardening is even more developed than in the previous type and consequently introduces new difficulties in handling technique. The oil companies found that this steel tended to become brittle at winter temperatures, although its impact resistance was regained at the temperature of boiling water. They therefore adopted the procedure of firing the pipes with steam after each shut-down.

The resistance of 5 per cent. chromium steel to oxidation at high temperatures is found to increase as the carbon content decreases. Since a decrease in carbon will increase the amount of chromium in solid solution, it is believed that the amount of chromium in this state is really the controlling factor. It has been found that the addition of such carbide-forming metals as molybdenum, tungsten, and titanium will also produce this effect. (*Metal Progress*, September, 1934.)—P. W. A.

SPRAYED MOLTEN METAL COVERINGS

THE importance of metal coatings in resisting corrosion, heat, and fire, in decorating, and in adding dimensions or weight to worn or mismachined parts has brought about a device for spraying molten metal coatings called the Metal-Layer Process. Metal is sprayed with a self-contained, portable gun. This tool melts, atomizes, and sprays any commercial metal fed in wire form to form coatings on surfaces of any size or shape. The molten metal is in fine particles and is "poured" by a jet of compressed air onto the surface to be coated, giving a unique control of results; the method is able to meet and satisfy requirements of strict manufacture.

With a standard spray nozzle at a distance of 5 inches, the spray covers a circle of 2-inch diameter. A single pass gives a thickness of 2 thousandths of an inch. The gun will melt and spray anything up to tantalum whose melting point is 5250° F. The wire is fed at speeds ranging from 10 feet per minute for high melting point wire to 34 feet per minute for low melting point wire. The weight of wire consumed per hour ranges from about 1¼ pounds for iron to 40 pounds for lead. The areas of metal coated to 6 thousandths of an inch vary from about 6 square feet an hour for iron to about 60 square feet for lead. The gun operates with oxygen and acetylene pressures from 13 to 15 pounds per square inch. The compressed air pressure ranges between 45 and 55 pounds per square inch. Special rotary, fan, and angle types of spray nozzles have been developed for metal coating where surfaces are inaccessible. This device may also be used to repair surface defects, to form current conducting coatings, and to do mass coating of small parts. (*American Welding Society Journal*, vol. 13, no. 9, pp. 16-20.)—J. C. W.

NAVAL ARCHITECTURE

(*Continued from page 111*)

diary might be worth publishing, and Mr. John Smith, afterwards rector of Baldock in Herfordshire, worked for three years unravelling the key. Later it was found that in the library both the shorthand and longhand copies of King Charles' adventure existed, so that had the collection been properly catalogued at the beginning there would have been no necessity for Smith's labors, the two accounts would have been as useful in deciphering the diary as the Rosetta stone was in giving the key to the Egyptian hieroglyphs.

While the student of humanity finds the diary a perfect mine of information as to the manners, customs, and ways of life generally of the Restoration period, the naval architect is much more interested in the records of the Navy and its ships which Pepys accumulated during his long service. The records which were actually made in those times were of course meagre from our point of view, and, such as they were, they were too often lost or buried in dusty corners of a store-house. Where possible Pepys retained the documents of importance, but where he could not do that he made copies which are today of great value. Perhaps the most interesting part of the collection is a book called "Fragments of Ancient English Shipwrightry" which was ancient in his day and really dates from the end of the Tudor period. Here we have a considerable amount of information regarding the Elizabethan ships. Of course much that we would like to know is omitted, and other details which technically were not important, such as the scheme of decoration and painting of the hulls, is carefully recorded, and it is from this record that the latest addition to the historical collection of old ship models in the Nautical Museum has been constructed.

One of the ship drawings has the under-water body of a ship made in the form of a fish, showing that even in those days the under-water form was being carefully studied by ship designers. In another, a naval architect is shown preparing the lines of the new ship. His principal instrument is a large pair of compasses and he is evidently endeavoring to find the center of a circle by means of trial and error. His costume which is highly decorative appears to be much padded and he wears a hat while at work, probably because the drafting room was entirely unheated in those days. His apprentice standing in similar dress but without the hat, wears a ruff, a small edition of the huge ruff which Queen Elizabeth made fashionable in order to hide her deformed back.

It is interesting to note that standardization was well understood in those days, as one of the drawings gives a profile of a ship with several different scales marked upon it so that one drawing would do for different sizes of a ship. Shipbuilding in those days of course was largely rule of thumb, the rules being kept as a trade secret and often descending from father to son, a process which did not lead to much development. Here again Pepys did useful work in bringing new blood into the construction corps of the Navy in the person of Anthony Dean. Dean was the first to foretell what the draft of a ship would be when launched. Just how he did it is not known, but Pepys says it was a thing which the king much admired in him, and indeed it must have been a considerable achievement for the year 1666. We remember that two hundred and fifty years later quite a number of ships drew must more water when launched than their designers had estimated.

After the death of Charles II his brother, the Duke of York, came to the throne as James II, but Pepys' friendship with James was a liability rather than an asset. James reverted to the Church of Rome and consequently was ineligible to remain on the throne, the act of union between Scotland and England having required that the sovereign should be a protestant and of the Church of England. This was inevitable since the king in England was the head of the church as well as the state. By the strong no-popery movement of the time Pepys was accused of catholicism and was for a time under a cloud. In the revolution when James II was deposed Pepys' official career was brought to an end. Although he was twice in prison for being a Jacobite, he was afterwards released and lived in retirement until his death, a little over seventy years of age.

Two things stand out prominently in his life: first, his assiduous care in recording events as they actually occurred, together with his acquisitiveness in getting documents and data to support his records. Secondly, his foresight in leaving this valuable collection to his old college where it would be available for the information and interest of mankind. This is best illustrated by the following quotation from his will:

"I do hereby declare that could I be sure of a constant succession of heirs from my said nephew qualified like himself for the use of such a library, I should not entertain a thought of its ever being alienated from them. But this uncertainty considered with the infinite pains and time and cost employed in my collecting, methodising, and reducing the same to the state wherein it now is, I cannot but be greatly solicitous that all possible provision should be made for its unalterable preservation and perpetual security against the ordinary fate of such collections falling into the hands of an incompetent heir and thereby of being sold, dissipated, or imbezelled."

The sentiments above expressed are as true today as they were in his time, and it behooves everyone owning records of contemporary events to see that they are handed over to some public collection. There are many historical records of the shipping of New England which are at present lying neglected in odd corners of old houses, and it is to be hoped that the possessors of these will see to them before it is too late. It is well to remember that Technology possesses a Nautical Museum where such things can be well preserved and available to all interested parties. The collection is already important and has been of much assistance to inquirers from many parts of the country, but there are still many gaps which it is earnestly desired will be filled.

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AIR CONDITIONING

(*Continued from page 110*)

compressor and condenser are located in the base. A fan in the top of the unit circulates air through a filter and the cooling coil, and discharges through a suitable grille or short duct into the room. In the winter the unit uses steam or hot water to heat the air, and provides water sprays to raise the humidity. The sound-isolating casing is made decorative to harmonize with the surroundings.

A similar type of unit may be applied to a central system in a residence. Air from the conditioned rooms is continuously circulated through the unit by the fan. An outside air connection provides a supply of fresh air, the amount of which may be fixed at a percentage of the recirculated air, or controlled by the relation between room conditions and outside conditions.

The central system may be installed in practically any residence, old or new. However, when it is possible to co-operate with the architect and builder in making the system an integral part of the home heating equipment, we approach the ideal installation.

In controlled systems the type and complexity of the controls depends upon the degree to which the system is to be automatic. A completely automatic system must keep the temperature and humidity in the room within the comfort zone and should follow the outside conditions in such a manner as to reduce the shock when one enters or leaves the conditioned space; it must automatically provide heat whenever needed in the summer and in the transition periods between summer and the heating season, but must prevent any cycling between cooling and heating. The largest quantity of air possible, without overloading the unit, should be provided. Automatic controls must also be able to take care of such incidents as a fire in a fireplace, or a large party, no matter what the time of year. Such controls are still in the experimental stage and may not be offered to the public for some time to come.

Curves C, D, and E, show the effect of different methods of simplification of controls. The controls were installed on one of our experimental installations at York. During the period represented by curve C, the operation of the compressor in the cooling unit was controlled by the room temperature. This method of control fails when the humidity is allowed to vary over an extremely wide range, even though the room temperature is regulated closely. Whenever the room was below the temperature which started the compressor, the humidity rose rapidly. This defect would not be so serious in a dryer climate.

Curve D shows the result of placing the control on room humidity. This produces a more comfortable condition but shows several unsatisfactory points. For instance, on August sixteenth with an outside shade temperature of 106 degrees our room temperature reached 69 degrees; this was due partly to the cool night which preceded the hot day. It shoud be noted that, during the period represented by this curve and the following one, an outdoor thermostat was arranged to cut off the compressor whenever the outside temperature dropped below a predetermined value. In curve E, we see the result of placing the room thermostat in series with the humidistat, the effect being to have humidity control as long as we did not pull the room down to too low a temperature. This method of control proved entirely satisfactory to the occupants of the house.

The conditions in an office installation are somewhat different; the simplest control often suffices. With room temperature control, the system shown in Fig. F gave very good results. It is interesting to note how closely the refrigerating machine balanced the load in this case, as during periods of occupancy the room temperature rose 1 to 2 degrees Fahrenheit. It is necessary to maintain a higher room temperature with the application of unit heaters than with direct radiation, because of the absence of a feeling of warmth caused by direct radiation from hot radiators. This is particularly true if desks are located under windows.

The problem of correct application so as to satisfy fully the many variations in requirements and personal reactions can be best solved only by diversified field test installations. Leading manufacturers have made a great number of experimental installations during the past several seasons. Very little has been published about this work, but, believing that it will be of beneficial interest, we are taking this opportunity to present some valuable findings on several of these plants. A chart under Fig. G compares duty, costs, and results obtained. The heating analysis is not included since its application was based on conventional practice and no unusual problems were encountered.

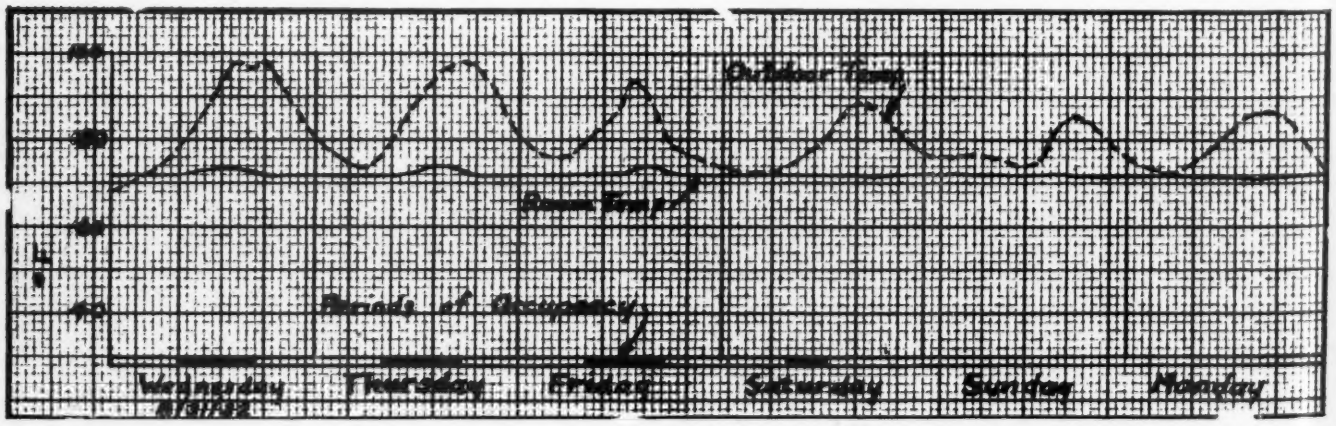


Fig. F.

TABULATION OF INSTALLATION AND OPERATING CONDITIONS

NO.	PLANT TYPE	DUTY	Approximate Installation Cost	REFRIGERATION OR COOLING LOAD: Calculated Tonnage 15° T. D.	Actual Tonnage Installed	T. D. Acquired	OPERATING COSTS OVER FIVE MONTH PERIOD: Total hrs. System Is Under Automatic Control	Power Cost at 3½c/Kwh	Water Cost at 20c per 1000 Gal.
1	RESIDENCE	Cooling and Heating	$1500	3.2	2.5	13°	590	$ 85.50	$19.44
2	RESIDENCE	Cooling	2000	2.65	2.0	8.5°	700	101.00	
3	OFFICE	Cooling and Heating	700	2.32	1.4	11°	450	31.40	
4	OFFICE	Cooling	850	1.61	1.3	20°	300	27.00	6.00
5	OFFICE	Cooling and Heating	1800	2.74	3.3	22°	300	54.00	12.00
6	OFFICE	Cooling	900	1.90	1.67	13°	400	36.00	8.00

Fig. G.

One residential installation under study (Fig. G, Plant No. 1) used during the first season a 1.6 ton plant for the sun room and living room and the second season applied the larger capacity unit with complete controls for regulating humidity, as well as room heat temperature, during the cooling period. It was observed that, when doors and windows were closed for periods of more than twenty-four hours, fresh air up to 25 per cent. was needed to prevent stale or dead odors. Furthermore, it was noted that to retain comfort the ratio of sensible cooling effect to moisture cooling effect must be varied with change in seasons.

The second plant constructed (No. 2) has been in operation for three seasons. Even with its apparent inadequate cooling effect, it gave satisfaction. During the past season very gratifying results were obtained even when the sleeping rooms, as well as the living quarters, were on the system twenty-four hours a day because of sickness. The feeling of comfort can be attributed to the reduction of relative humidity and to the uniform air distribution throughout the occupied space.

Plant No. 3 was considerably under capacity, but fairly comfortable conditions were obtained by using small quantities of fresh air during the worst conditions. Also, a desk fan was used to give better diffusion of the cooled air from the unit, thus actually improving the air movement in the room.

The temperature of the air in the offices of plant No. 4 was controlled separately. It was found to be a distinct advantage since the occupants found it more satisfactory to choose their own conditions. The condensing unit and one cooling unit were hidden conveniently in closets. An installation of this type is very suitable for professional offices.

In plant No. 5, a general office with the executive office separated by partitions, two condensing units were put in parallel so as to balance the requirements. A sound-proof enclosure was built up around these condensing units, which were placed in the general office space. Very satisfactory conditions were obtained in both summer and winter.

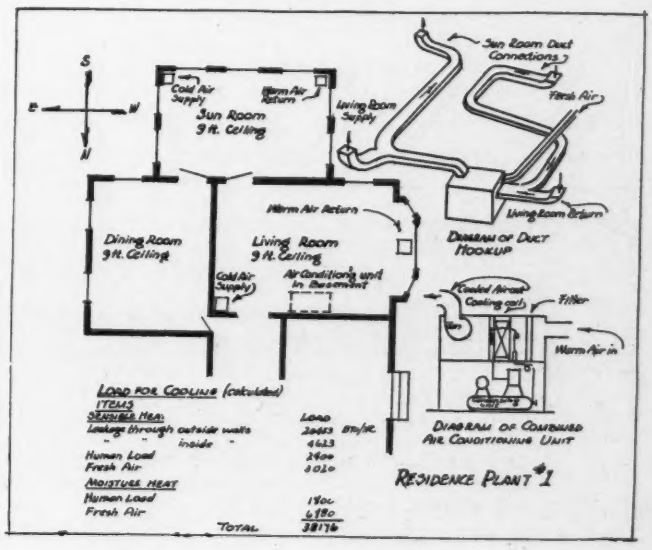
Two offices, in plant No. 6, at considerable distance from each other, were handled by one condensing unit. In the case of one office, the cooling unit was concealed in the upper part of a closet. Satisfactory control was easily obtained. The calculated tonnage appears to be more than adequate, because conditions were calculated for the worst combination of high outside temperature, high relative humidity, and full quota of fresh air. The simultaneous peak of all three factors is seldom realized, and it is probable that these recorded conditions do not represent this extreme, but they do cover the heaviest load experienced in the records of the installations.

This analysis shows that, on unit installations, comfort can be realized with somewhat less than the normal calculated loads, provided that satisfactory diffusion is obtained and the units are properly designed and applied.

The application of comfort cooling to small spaces is justifiable from an economic standpoint. This is particularly true in respect to shops, offices, and restaurants. In addition to these applications, its use in residences, hotels, and hospitals is increasing.

Many types and classes of apparatus are already on the market, and it is anticipated that many more will be offered during the next two years. The research and development work under way will involve many more features both new and useful; it is anticipated that within a few years new systems will be presented which

(Continued on page 120)



ASTRONOMICAL PROGRESS

(*Continued from page 105*)

mer is sure to put every part of the instrument to a rigorous test. The engineer and astronomer will both watch with interest the plans that are now being evolved for the mounting of the 200-inch telescope, which will be on such a large scale that there will probably be room for two small spectroscopic laboratories right in the polar axis!

The 200-inch telescope has already, in the "blueprint" stage of its development, given considerable service by stimulating investigations that have led to the construction of useful pieces of auxiliary apparatus. One of these is the so-called "zero corrector" designed by Dr. Ross of the Yerkes Observatory. It consists of a lens system placed just inside the focus of the large mirror, the function of which is to change the curved focal surface of the telescope mirror into a plane. Photographs taken with large reflectors give only a good focus over an area with a diameter of about one inch, if the zero corrector is not attached to the telescope; however, the whole area covered by an 8 by 10 inch plate is in good focus if use is made of the zero corrector. A second interesting discovery, which was at least partly stimulated by the plans for the 200-inch mirror, was the successful working out of the process of aluminizing telescope mirrors. It has been the rule in the past to cover the reflecting surface of a mirror with a coat of silver; this practice has always had several disadvantages, chief among which were the facts that a silver coating scratched easily, that it deteriorated quickly, and that its reflecting power was very low for the violet end of the spectrum. The aluminum coating, which can be put on by a process of evaporation in a high vacuum, is permanent, does not scratch, and has such a high reflective power in the violet that a new part of the spectrum has already become accessible to large telescopes.

This article would become far too long if I enumerated the outstanding developments in engineering and physics of which the astronomer has been able to make use. Practically all recent improvements in photographic technique have been found useful to the astronomer, and to take only one example, the new fast red-sensitive plates that have come into the market will tell us probably in the near future a good deal more than we know at present about the nature of the "cosmic dust" that appears to be present throughout interstellar space.

With the exception of the process of aluminizing mirrors, most of the technical developments that we have discussed have been more in the nature of improvements of technique than of startling discoveries. We must not forget, however, that progress is made primarily by means of devices that make use of an entirely new idea, or that embody a fresh attack upon an old problem. Astronomy is at this moment crying for developments which are more than simple improvements. Photographic technique offers, in spite of its many successes, some of the outstanding examples of field for invention. Measurements of the color of a faint star are both difficult and tedious and at the same time liable to be affected by a great many sources of error. Astronomers determine the "color index" of a star by measuring the star's brightness first from a photographic plate sensitive to blue light, then repeat the measurement from a plate sensitive to either yellow or red light, and use the ratio of both brightnesses as a measure of the star's color. The method is about as clumsy as it can be. It is as though we would measure the height of a tree on top of a hill by determining first how high the top of the tree is above sea level, next how high the foot of the same tree is above sea level, and finally get the desired result by taking the difference between both heights. Where is the engineer, physicist, photogapher, or chemist who can give us a better method for getting after the color of objects which are so faint that we cannot get spectra of them?

Some of the outstanding successes in astrophysics—and, incidentally, the same holds for physics and chemistry—have been obtained by making photographic exposures that take pretty close to one hundred hours. The energy is there at any one moment, but it takes the photographic plate a long time to record it. The question is probably most serious for the astronomer because of the loss of valuable telescope time. There exists at present an elaborate photoelectric technique with tremendous possibilities for amplification. The astronomer cannot help but look forward to the time when long exposures on cold and crisp New England winter nights will be no longer needed, and the engineer who discovers what is going to supersede the photographic plate will probably save the lives of a few good astronomers that otherwise might have died from pneumonia.

I am afraid that this article may have been written

(*Continued on page 120*)

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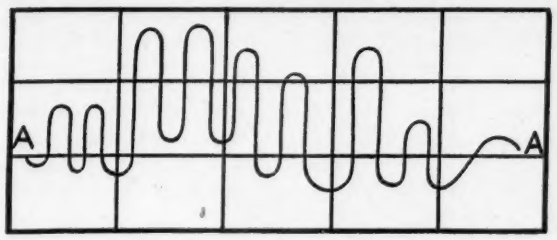

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Astronomical Progress

(Continued from page 118)

somewhat as though it were entitled: "Engineers Awake." I apologize to those who point out that the astronomer should not nag at the engineer about the future when there is already so much that he has to thank him for in the past. But I do hope that I have succeeded in demonstrating that astronomy offers a fertile field for engineering activities. One of the things which astronomy needs most today is to get some young engineers interested in astronomy as a hobby. If they only get into the habit of dreaming about the universe of stars and galaxies, they cannot help becoming periodically annoyed at the clumsy technique of the astronomer, and they should be able to contribute to the progress of science by teaching astronomers how things should be done.

Air Conditioning

(Continued from page 117)

will be much more economical in the initial and operating costs, and that they will become a fundamental part of the heating system. In view of the fact that there are so many types of apparatus to select from, it is recommended that a prospective buyer analyze his needs carefully so as to make sure that the apparatus he pays for is designed to meet his requirements properly. This will make the customer happier and bring the industry, as a whole, nearer the ultimate goal.

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Editorials

(Continued from page 112)

of the headlines which is sound and reasonable from that part which is intended solely for increasing the newspaper's circulation. Obviously, the chance to prevent such a condition comes during the school education of the citizen. Since the colleges come in contact with only a small proportion of the American people, the work would best be undertaken during the high school period.

Consider the average high school curriculum. In addition to mathematical, scientific, and vocational courses, the student takes such cultural subjects as English, Latin, a modern language, and history. Because the schedule is comprehensive and because it does not put too much emphasis on any one line of study, the schedule is, potentially at least, a good one. Except for the general aim of a broad education, however, the high school curriculum lacks a definite goal. Especially among the so-called cultural studies there is an absence of correlation. Latin, for example, is considered a separate entity, more or less distinct from history and economics. But the value of Latin as a mere collection of words and forms of grammar is far exceeded by its value as an opportunity to glimpse, almost at first hand, the customs and history of the world at the time of the Roman Empire. In a similar manner, the study of a modern language could be conducted so that the history and political problems of the country whose language is being studied could be considered in addition to mere grammatical instruction. History courses themselves, instead of being concerned solely with dates and the succession of events, should devote more time to outlining the national development and to pointing out the effects of happenings in other countries on the history of America. American history should be a consideration of the development of the American people and of the factors which influenced that development. Once the student has acquired a critical and analytical knowledge of American history and its relation to world history, the next step is the introduction of a course surveying contemporary economics in order to give him a fair understanding of the monetary and commercial problems which confront America and the rest of the world. By thus focusing a large portion of the high school course on the study of government, it is possible to create in the student an unconscious interest in political and economic affairs. As a result, his ballot is the consequence of what his knowledge leads him to believe and not the consequence of the campaign propaganda.

ANNOUNCEMENT

THE Managing Board of THE TECH ENGINEERING NEWS wishes to announce the resignation of Scott C. Rethorst '36 from the position of Advertising Manager, and the election of E. Hibbard Summersgill '36 to the post. Members of the sophomore class may compete for positions on the magazine.

MOTHER USED TO MAKE THEM—You expect good things to eat from the modern gas range that combines beauty with convenience and economy in cooking.

Progress Means Change

Oxy-acetylene Welding Helps Stove Manufacturers and Others Overcome Initial Factory Costs of New Models

G. O. CARTER*

Once, there were no other means of fabricating metal products except through huge investments in patterns, dies and special tool equipment. Naturally, it was logical for the plant to resist Sales Department pressure for too frequent design changes. Capital investment had to be amortized first.

Now, it is no longer necessary to place this handicap on the sales organization and keep it fighting for sales counter to consumer demands.

Welding Lowers Cost of Stoves

Modern gas ranges, for example, are assembled from a considerable number of enameled sheet steel panels of different sizes. Former manufacturing methods required a set of dies for each panel. The total investment in dies for an ordinary stove in many cases involved several thousand dollars. With such a large investment factories were naturally reluctant to make any change involving the scrapping of dies until enough stoves of a particular model had been manufactured to absorb their cost.

Many large gas range manufacturers now use welding in the fabrication of stove panels and eliminate the necessity for dies. The sheet steel is cut to required size on standard shears; the corners punched out on standard machines; the edges turned up on standard brakes and—the corners are welded.

INVISIBLE JOINTS — Welded corners make a sturdier stove — eliminate chipping of enamel in assembly and in use.

Welding Is Modern

By adopting welding and cutting these manufacturers have largely eliminated factory resistance to consumer change. This flexible means of production easily permits improvement in current models, or redesign without serious breaks in plant operation, or increased capital investment.

The total cost of operation by the new method is not only lower but it is now possible to follow consumer demand quickly without the necessity of scrapping expensive equipment.

Used in Many Industries

The experience of the stove manufacturer is duplicated in many industries. Redesigning metal products and equipment for welded construction has resulted in increased strength, utility and permanence. It has been adopted for metal furniture, loud speakers, refrigerators, display signs, sheet metal desks, stainless steel barrels, hoes, truck bodies, and numerous other articles. Welding is applicable to the widest range of materials—steel and the ferrous alloys—aluminum, brass, bronze, and practically all other non-ferrous metals and alloys. Welding is ideal for applications where smooth, invisible joints are necessary for enameling.

Wealth of Experience

The application of oxy-acetylene welding and cutting to your production problems need not be deferred because it may seem difficult. Linde Development Engineers will work with you and offer valuable engineering assistance in product design—or redesign. The Linde organization can focus upon the problems of one user the combined experience of thousands and day-by-day discoveries of a large research staff. It may be able to help you. Consult the nearest Linde Sales Office —without obligation. Linde Sales Offices are located at Atlanta—Baltimore, Birmingham, Boston, Buffalo, Butte—Chicago, Cleveland—Dallas, Denver, Detroit—El Paso—Houston —Indianapolis—Kansas City—Los Angeles—Memphis, Milwaukee, Minneapolis—New Orleans, New York—Philadelphia, Phoenix, Pittsburgh, Portland, Ore. —St. Louis, Salt Lake City, San Francisco, Seattle, Spokane, and

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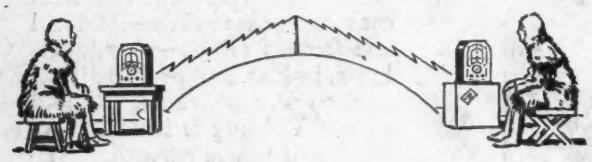
*Consulting Engineer, The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation. —This being a Business-News Advertisement.

G-E *Campus News*



TWO POLES IN ONE

Radio entertainment and "airmail" have been sent to the Antarctic through General Electric's short-wave station W2XAF, ever since Rear Admiral Byrd arrived there last year. Recently, in conjunction with a Byrd program, another was sent out to Rockwell Kent and his son in the Arctic region—thus linking simultaneously Americans who are, in the matter of latitude, farthest apart. Governor McNutt of Indiana and other prominent Hoosiers spoke to the Byrd Expedition from Indianapolis in a program sponsored by the *Indianapolis Star.* Immediately afterward, the Coffee House Club, an organization of artists and writers to which Rockwell Kent belongs, sent music and greetings from New York to him on the island of Ubekjent, just off the coast of Greenland, 600 miles within the Arctic circle. Features of this program were special greetings from Mrs. Kent and her daughter, and a talk in the Eskimo language by Vilhjalmar Steffanssen, Arctic explorer, for the benefit of the natives. Both programs were broadcast over a coast-to-coast NBC network as well as by short waves.

GOOD-BYE, SMOKESTACK

For many years, the old central heating plant at Mt. Holyoke College in Massachusetts, with its tall, unsightly smokestack, barred the way to certain necessary improvements and landscape developments on the campus. This summer the old boilers and the smokestack were torn down. In one of the buildings of the old plant stand 120 General Electric oil furnaces arranged in circular groups of five. Fifty-two more G-E oil furnaces are installed in the smaller or more isolated buildings of the campus, operating singly, in pairs, and, in one instance, in a battery of 10. In the central plant, only as many groups of furnaces will operate as are necessary to maintain the required steam pressure. The remainder will be shut down, avoiding stand-by losses. The individual furnaces and small groups in distant buildings permit the abandonment of some of the longer runs in the underground steam-distribution network. The high efficiency of the system is expected to produce savings which will pay for the installation in five to seven years. In addition, as a result of the more careful regulation of temperature, it is expected that health conditions at the college will be considerably improved.

The main plans for the system were drawn up by C. W. Colby, consulting engineer. D. W. McLenegan, Wisconsin, '21, assistant engineer of the Air Conditioning Department; W. O. Lum, and H. R. Crago, Penn State, '18, both of the same department, handled engineering details for General Electric.

FLYING POWER PLANT

Gold was discovered in 1925 along the Bulola River in New Guinea, an island just north of Australia. Prospectors worked the richer veins by hand methods, and packed their "take" on the backs of natives through 40 miles of cannibal-infested and nearly impassable jungles to Lae on the coast. After the best veins had been worked out, it became apparent that placer operations on a large scale would pay if the necessary dredges and other machinery could be brought to the location. Land transportation was impossible, so a plane was sent in. The pilot found a spot to land, and a flying field was cleared off.

Four 875-kv-a. General Electric waterwheel generators were among the equipment ordered. When they arrived at Lae, they were transferred to huge all-metal Junkers freight planes and flown to the location piece by piece. The largest single pieces had a net weight of 6545 pounds. As the load limit of the planes is 7000 pounds, it was a tight squeeze. D. B. Gearhart, Iowa State, '27, of International General Electric, Inc., handled the order for the Company.

96-83DH

GENERAL ELECTRIC